# EEE Parts Risks and Concerns

## Commercial Off The Shelf (COTS)

### Presentation to GSFC Code 300

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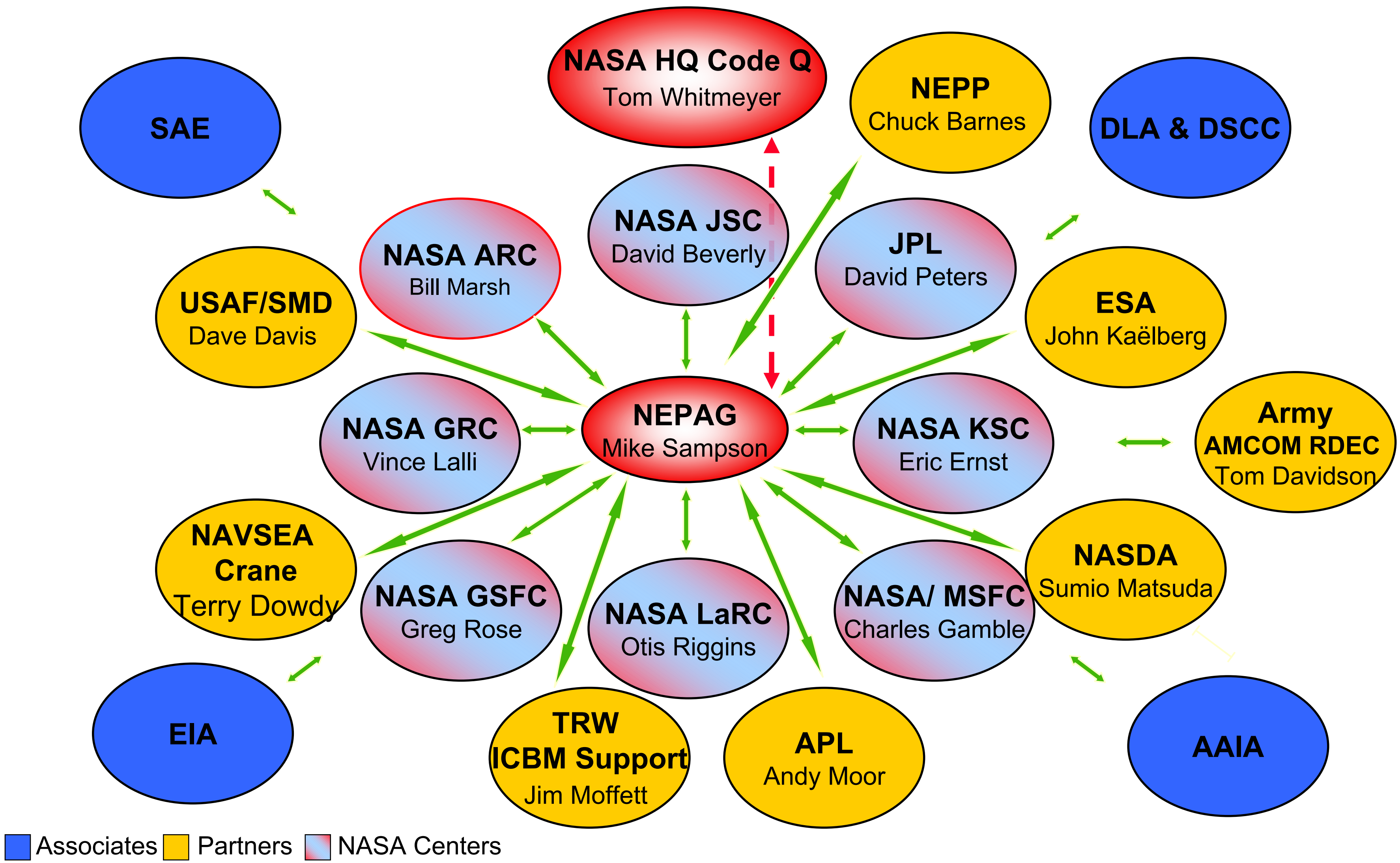
# Overview

- The NASA EEE Parts Assurance Group
- Commercial-Off-The-Shelf (COTS) Parts
- Cost and Cost Estimates
- Cost Related Conclusions
- Benefits and Benefit Analysis
- Cost/Benefit Driven Strategies

# NEPAG Charter

- Provide knowledge, tools, information and resources to assist project EEE parts engineers and parts specialists in guiding parts selection decisions by designers and projects
- Promote quality and reliability assurance processes that eliminate EEE part failures from the advanced stages of the project life-cycle.

# NASA EEE Parts Assurance Group



# Commercial-Off-The-Shelf (COTS)

## FAR 2.101 Definition:

- Any item, other than real property, that is of a type customarily used by the general public or by non-governmental entities for purposes other than governmental purposes, and has been sold, leased, or licensed to the general public; or has been offered for sale, lease, or license to the general public

# Two Principal EEE Parts Options

## Military/Hi Rel

- Known performance
- Specification driven
- Controlled/monitored sources
- Consistent requirements
- Known traceability
- Change notification
- Interchangeability
- Use-as-is or minor upgrading
- Older technologies
- Long lead times
- High procurement costs

## Commercial-Off-The-Shelf (COTS)

- Unknown performance
- Commercial market driven
- Unmonitored sources
- Variable market driven requts
- Variable traceability (none?)
- Limited change notification
- Vendor specific variations
- Upgrading for assurance
- Newest technologies
- Short lead times
- Low procurement costs

**The 80/20 Rule Applies**

# The 80/20 Rule

- Also known as Pareto’s Principal (1906)
- 80% of revenues are generated from top 20% of customers
- Commercial products are optimized for the top 20%
- Rarely does NASA’s business amount to 1%
- AND it is usually invisible, as contractors do our procurement

# NEPAG Risk Matrix (Inherent Risk)

| Part Groups | Low | Medium | High | Unknown |
|---|---|---|---|---|
| General | NPSL Level 1<br>975 Grade 1 | NPSL Level 2<br>975 Grade 2 | NPSL Level 3<br>Vendor Flow | COTS |
| Actives | MIL Class S,V,K<br>ESA Level B LAT2<br>NASDA Class I | MIL Class B,Q,H<br>ESA Level C<br>NASDA Class II | MIL 883B<br>QML<br>M,N,T,D,E | COTS |
| Passives | MIL S/R Failure Rate<br>ESA Level B<br>NASDA Class I | MIL P Failure Rate<br>ESA Level C<br>NASDA Class II | MIL M/L Failure Rate<br>DSCC Drawing | COTS |

# COTS Risk Factors

- Lot-To-Lot Variation/Frequent Process and Design Changes
- "Lots" Can Be Mixes of Sub-Lots of Different Origins
- Integrity of Plastic Packages Difficult to Assess
- Manufacturer Reliability Data May Contain Unidentified Biases and Have Limited Relevance to Procured Parts
- Design Margins Minimized, Considerably Less Conservative Than Military
- Limited Operating Temperature Range
- Minimal Screening Determined by Primary Market Needs
- Rapid Obsolescence
- Radiation Hardness is NOT a Selling Point

# Traceability?

# COST

- Cost is the <u>Total Cost of Ownership</u>
- For EEE parts this includes, purchase, qualification, screening, radiation hardness, handling and fallout costs

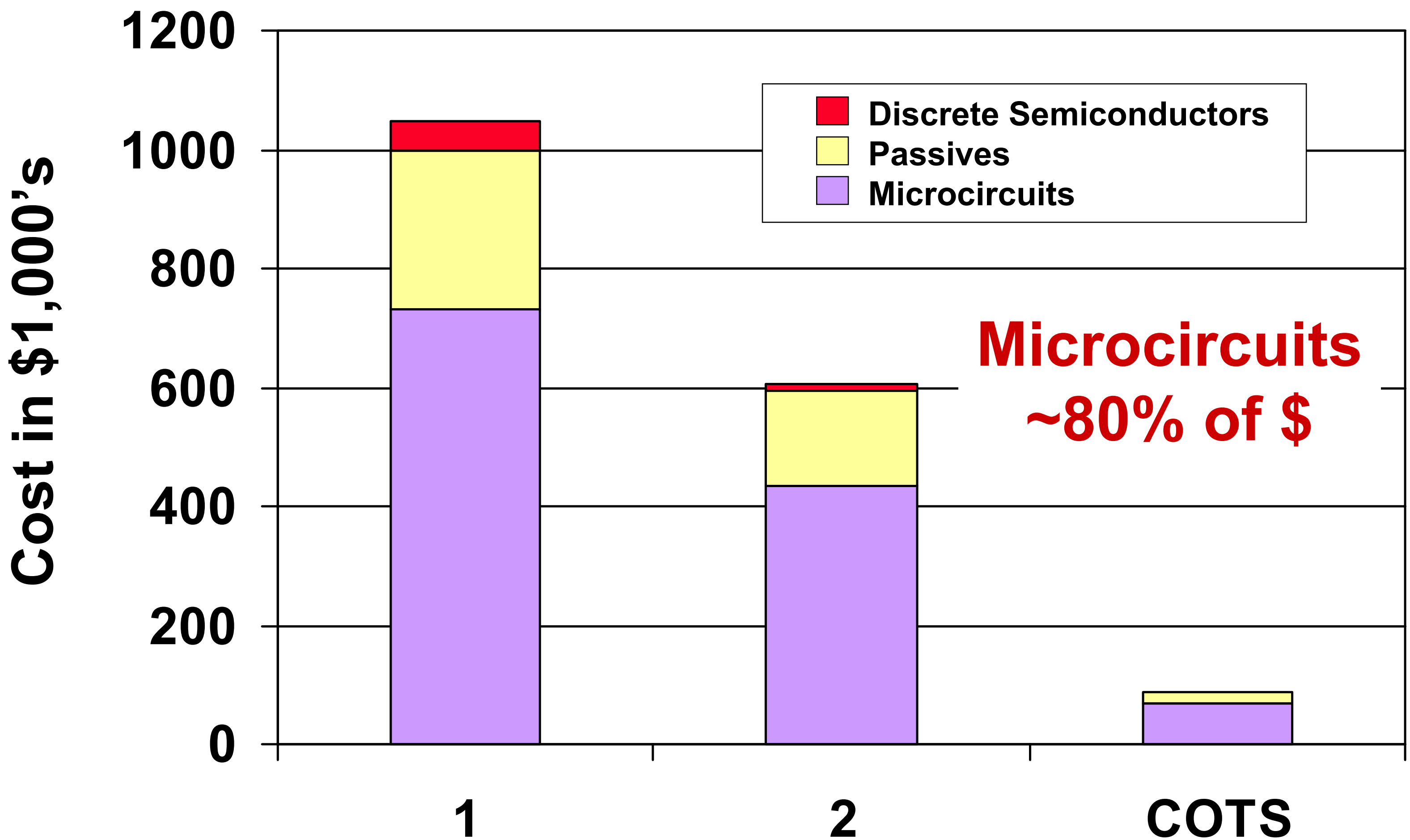
# The Cost Contribution of EEE Parts

- "Best Guess" estimates from informed sources say EEE parts are typically <8% of overall project costs
- Actual figures are difficult to derive
- Two instances where cost data is available:
  - Space Station - 1.2% (1994)
  - Mars Pathfinder - 2% (1998)
- Despite the small contribution to overall cost, EEE parts are frequently targeted for cost savings
- Probably the only cost factor that appears easy to control and to offer savings late in the project cycle

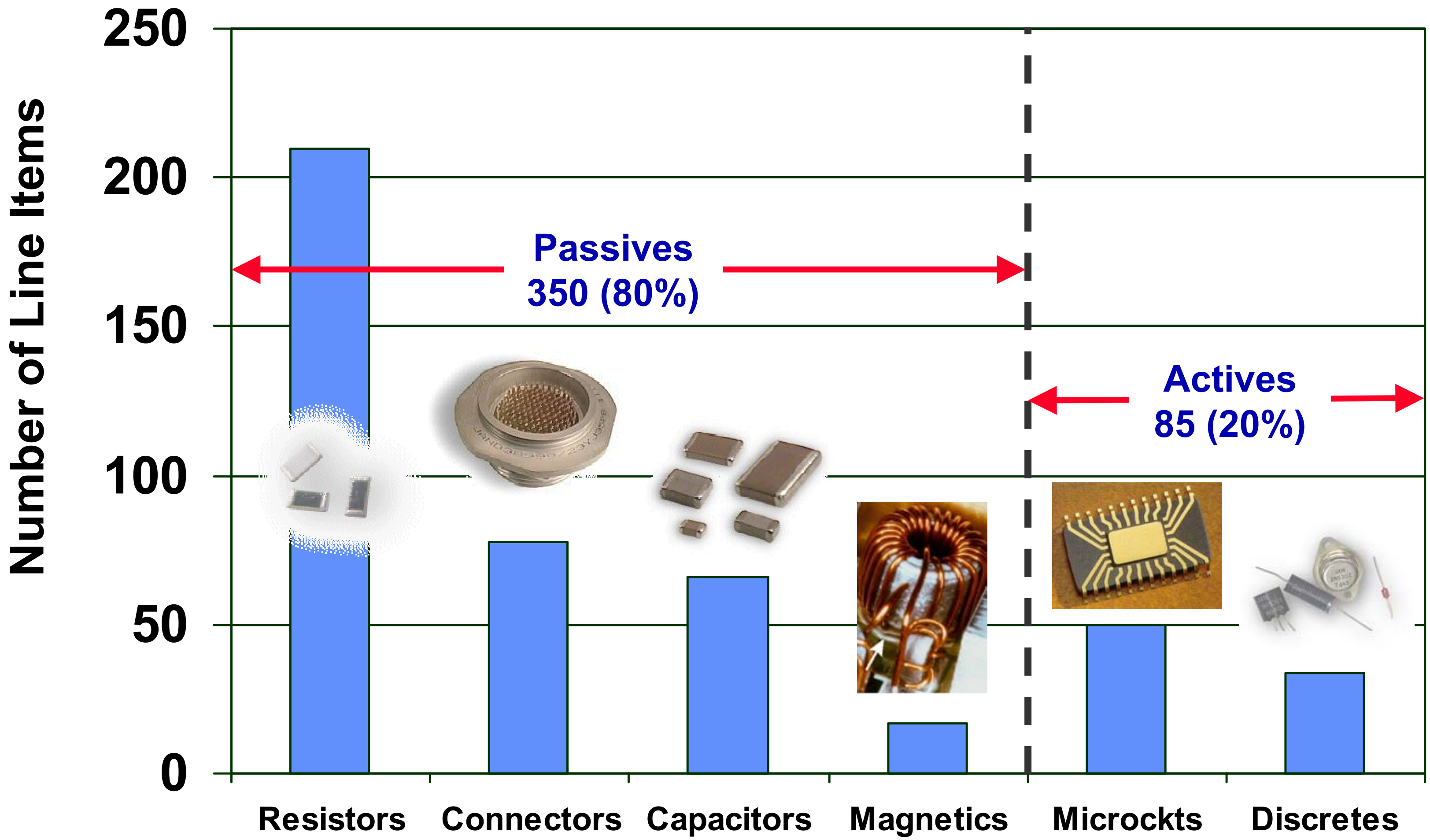
# NASA Cost Model

- Utilizes Parts Lists from Current NASA GSFC Flight Projects
- Partial Lists for Three Instruments and One Spacecraft
- Difficult to get Complete Lists for a Whole Project Due to Extensive use of Off-The-Shelf “Boxes”, Fixed Cost Procurements, Multi-Organizational Cooperative Ventures
- Overall Model is “More than an instrument, less than a spacecraft”
- Procurement Costs for the Parts in the Model List were Obtained at 3 Reliability Levels, 1, 2 and COTS
- Where the Exact Part was not Available at all 3 Levels, Closest Equivalents were used

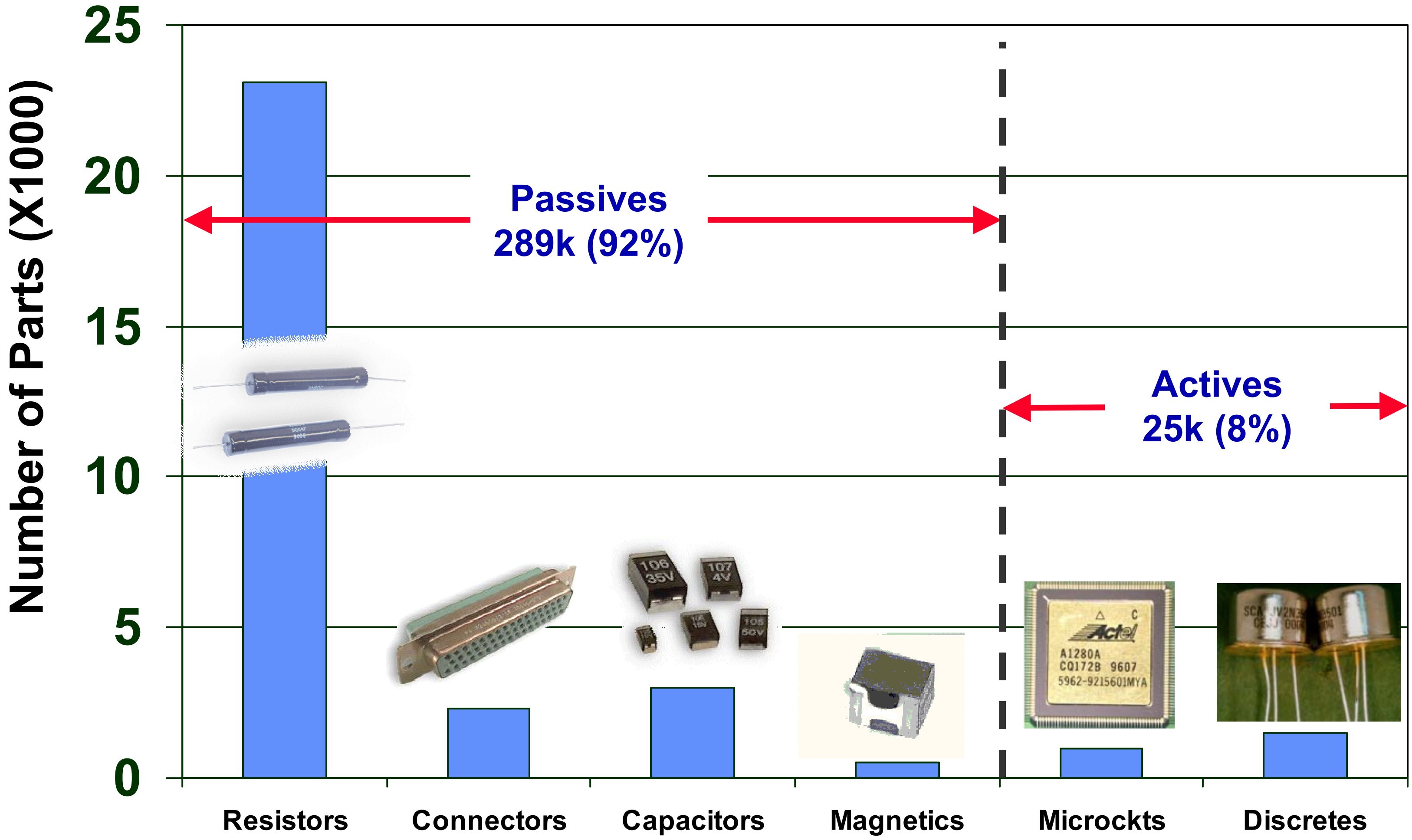
# Purchase Cost For The NASA Model



# Our Cost Model By Line Item



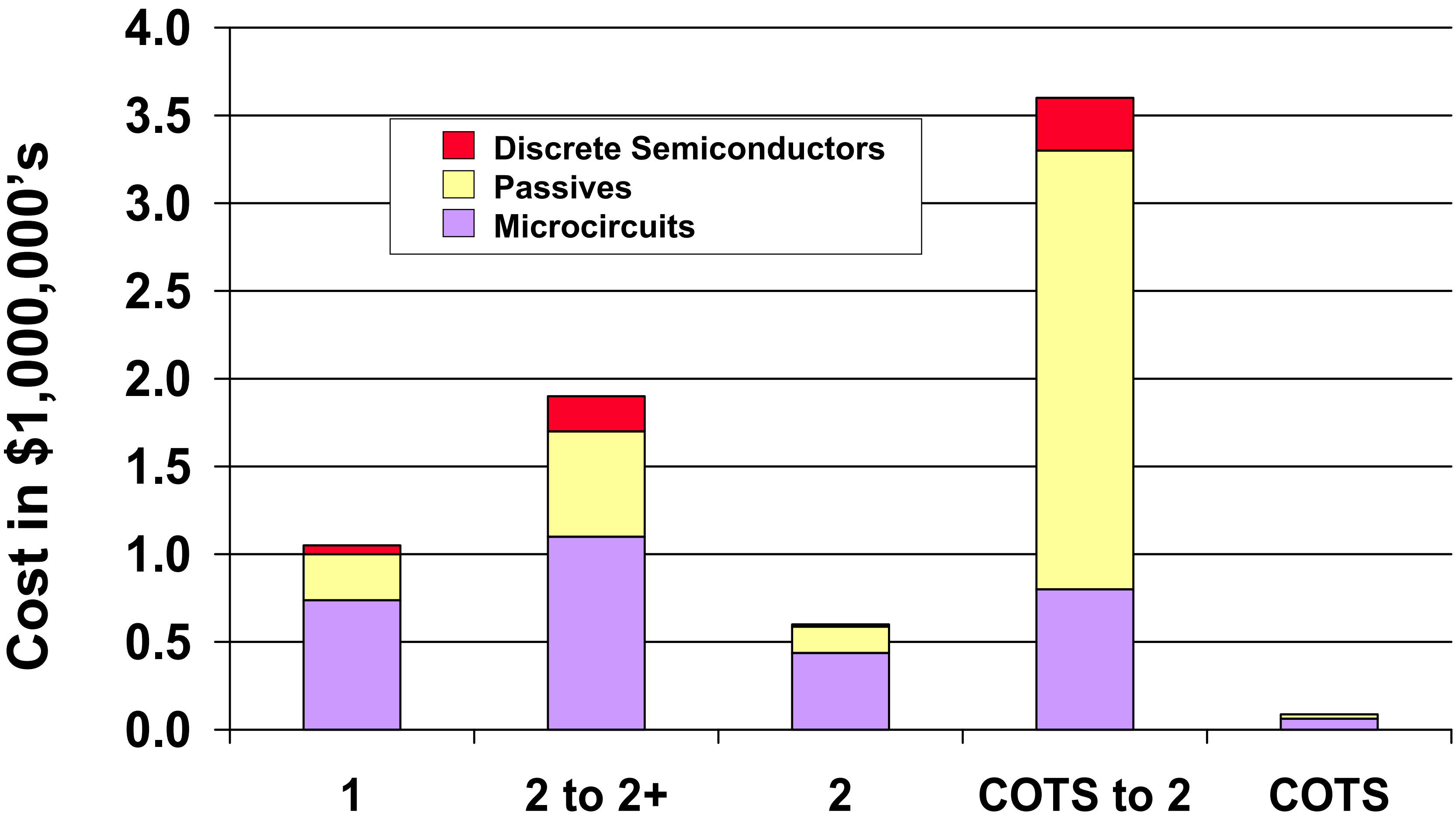
# Our Cost Model By Parts Count



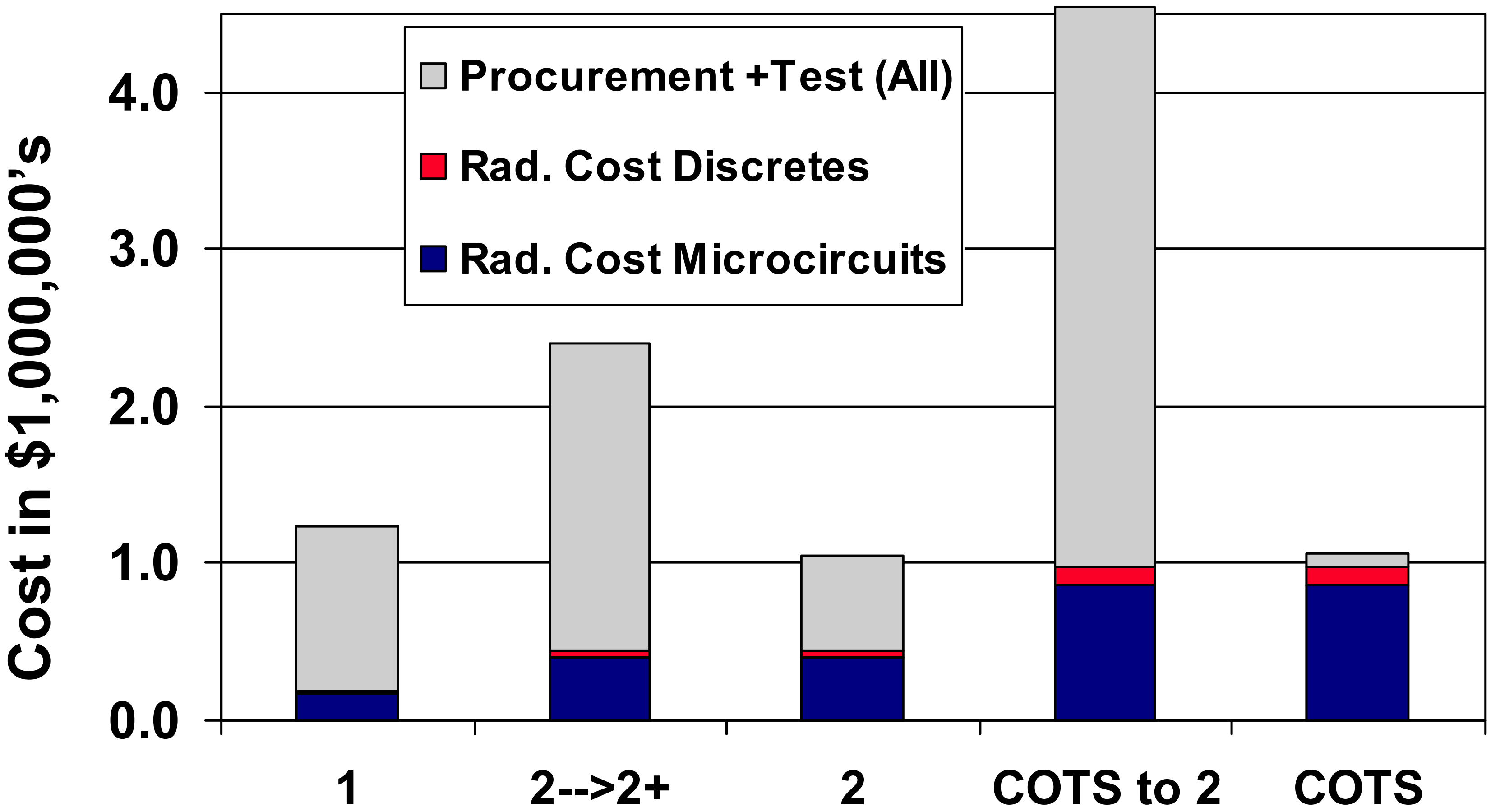
# Cost-Related Conclusions

- If Passives Were Free, the Savings Would Be Minimal, Only ~10% Of the Overall Parts Purchase Cost
- At 90%of the Parts Count, Risk From Passive Part Failure is Proportionately High
- Ample Supply in Reasonably Current Technologies is Available For Discretes and Passives at the Highest MIL Spec Levels
- It is Not Logical To Incur Unknown Risk From Use Of COTS Passives Or Discretes Unless Justified By Other Than Cost
- #1: Use The Best Grade Passives And Discretes Available

# Impact Of Upgrading On Parts Costs



# Impact of Radiation Assurance With Upgrading On Parts Costs (incl. parts cost)



# Costs Sanity Check

- Independent Cost Assessment by Group of Domestic Aerospace OEMs
  - Plastic Encapsulated Microcircuits (PEMs) Only
  - Estimated $13.25k/Line Item For Screening, NASA $13.2k
  - Model Also Adds ~$30k For Package Qual
  - $5k For TID, NASA $10k
  - $47k For SEE, NASA $35k
  - Test Boards and Programming (NRE) Can Be $100k+/Line Item
- Independent Air Force Estimate of $15k/Line Item

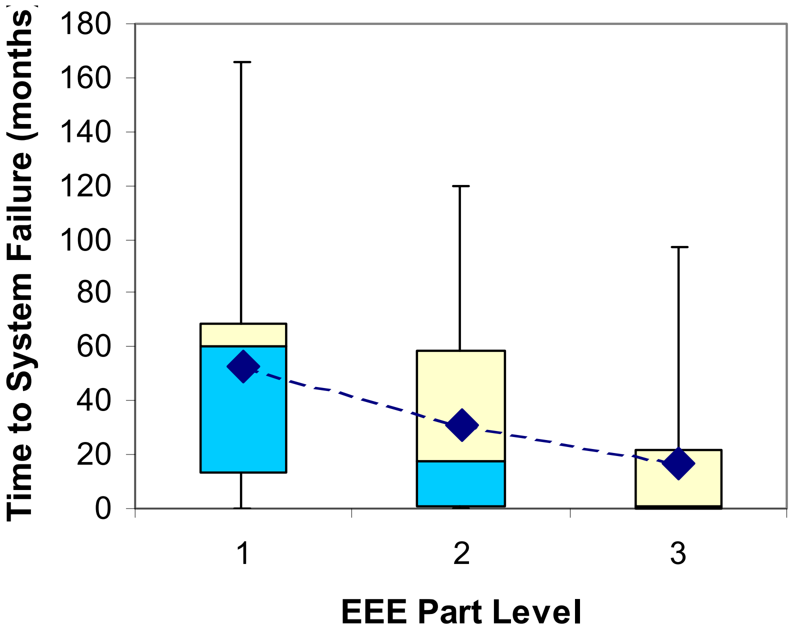
**NASA Model is <u>Conservative</u>, Actual Costs are Probably <u>Higher</u>**

# More Cost-Related Conclusions

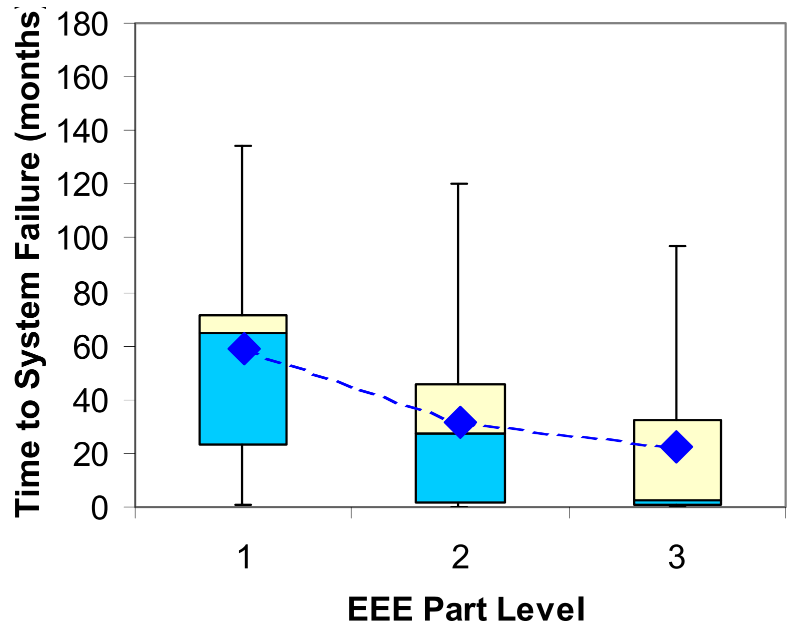
- Upgrading Is Costly
  - BUT Currently Considered Essential
- Level 1 Microcircuits May Have The Best Cost Of Ownership
  - Level 2 If Upgrading Is Not Required
- COTS Microcircuits Upgraded to Level 2 cost About the Same as Level 1 Until Radiation Is Figured In
- #2: COTS Makes Economic Sense If Upgrading Can Be Avoided
- #3: Use Unscreened Level 2 Microcircuits If The Risk Is Acceptable and Required Functionality Is Available
- #4: Avoid Upgrading
- #5: COTS Should Only Be Used By Exception, for Essential Functionality or for Availability

**NOTE: Radiation Assurance is Required On a Lot-By-Lot Basis for Actives, Most COTS Lots Require Testing.**

# Time To System Failure On-Orbit




**All Except Impact, Launch and Explosion**




**High Probability EEE Part Categories**

# Our Data

- Earth Orbit Data, for Past 20 years, From an On-Line Service
- 1483 International Science and Commercial Satellites Originally Investigated
- 223 (14.9%) Experienced Some Kind of Failure, 247 Failure Incidents (1.1 / Spacecraft)
- 4.1% Were Launch Related, the Biggest Category, We Excluded Them From Our Analysis
- 157 System Failures Analyzed, Excludes Eastern Data Considered Unreliable
- Each Satellite Categorized by Its Probable EEE Parts Reliability Level
- It is Assumed Bearing, Solar Panel, Propulsion, Battery and Software Failures Randomly Distributed Across Mission "Classes"
- It is Therefore Assumed That the Differences Between EEE Parts Selection Have An Influence On Observed Satellite Success

# Cost/Benefit Driven Strategies

- It is Not Proposed We Ignore the Enormous Potential Offered by New Technology, Available Only As COTS
- It is Proposed We Adopt a Wise-Use Strategy
- As Already Emphasized, Buy the Best Passives and Discrete Semiconductors Available Whenever Possible
- For Routine Circuit Functions Level 1 or 2 MIL Spec Active Parts Should Be Used, When Suitable and Available. Level 1 For Critical Missions and Functions, 2 or 1 Everywhere Else
- Use of COTS Should Be Limited to Applications Where the Size, Weight, Speed, Memory or Other Characteristic of the Technology is Essential to Mission Success.
- COTS Use Is Also Justified If Availability Is Critical to Meeting Schedule and the Cost of Ownership is Acceptable

# Cost/Benefit Driven Strategies

- **Consider Integrated Product Teams (IPTs) For Acquisition of COTS**
  - **Multi-Disciplinary, Assurance, Engineering and Procurement**
  - **Each Teams Specializes on a Few Manufacturers and Gets to Know Them Well, Quality, Reliability, and Business Performance**
  - **Teams Track Changes, Provide Early Warning of Potential Issues**
  - **Enables Selection of Sources Who Provide Products That Require Limited Post Procurement Testing**
  - **Facilitates Record Keeping, Information Exchange, Common Buys**
  - **(Generates FAR Compliant Preferred Suppliers List?)**
  - **Objective: Realize Cost Benefits of COTS By Minimizing Upgrading**

Some manufacturers offer “Enhanced” COTS that address some traceability, change control and temperature range issues. This initiative needs to be encouraged

# Recent Developments

- **Aerospace Qualified Electronic Component (AQEC)**
  - **"One page" spec *DRAFT***
    - **Provides general "envelope" of requirements**
    - **Temp range –40C to +125C**
    - **Documented processes**
    - **Performance assessment over qual'd temp range**
    - **Expected lifetime in data sheet**
    - **Stable configuration for at least 1 year post qual**
    - **Does not require change notification, single flow etc.**
  - **TI "Enhanced Plastic" Goes Further**
    - **Better than straight COTS even if upgrading still required**

# General Conclusions

- A Cost/Benefit Driven Strategy for EEE Parts Selection for Space Flight is Essential for Mission Success
- Cost Factors are Highly Variable, Box to Box, Project to Project BUT Upgrade Testing WILL BE EXPENSIVE
- Cost Models Will Vary Widely Dependent on Assumptions Used but the NASA Model is Conservative
- Benefits are Harder than Costs to Estimate But Trend Supports the “You Get What You Pay For” Adage
- Inherently Space-Grade Parts Afford the Lowest Cost of Ownership

# BACK-UP SLIDES

# Our Cost Model - Upgrading

| | | Fraction of Line Items To Test | | | |
|---|---|---|---|---|---|
| **Device** | **#Line Items** | **2->2+** | **COTS to 2** | **Cost for Elect + DPA** | **Cost for Elc+DPA+Env** |
| Resistors | 210 | 10% | 100% | $5000 | $7250 |
| Capacitors | 66 | 50% | 100% | $5000 | $7250 |
| Magnetics | 17 | 90% | 100% | $6875 | $9875 |
| Connectors | 68 | 50% | 100% | $3500 | $4100 |
| Discretes | 34 | 50% | 100% | $7050 | $8550 |
| Microcircuits | 50 | 60% | 100% | $11700 | $13200 |

**These Costs Include A Minimal Estimation For Non Recurring Expenses (NRE)**

# Our Cost Model - Radiation

| | Single Event Effects (SEE) | | | | Total Ionizing Dose (TID) | | | |
|---|---|---|---|---|---|---|---|---|
| | Line Items for Testing | | | Cost | Line Items for Testing | | | Cost |
| | Level 1 | Level 2 | COTS | $/Line Item | Level 1 | Level 2 | COTS | $/Line Item |
| **Discretes** | 2% | 7% | 20% | $15k | 0 | 5% | 10% | $5k |
| **Micrckts** | 10% | 20% | 35% | $35k | 0 | 10% | 50% | $10k |

EEE Forum - Netscape 6

http://eee.larc.nasa.gov/forum/Default_2.htm

# NEPAG

# NASA EEE Parts Assurance Group

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Register

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- Aerospace Corporation
- ESA
- JHU/APL
- MACOMB
- NASA
- NASDA
- NAVY NAVSEA/Crane
- US Air Force/SMC
- US Air Force/TRW ICBM Support Group

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# The Growth in Spacecraft On-Orbit